

NOTES ON THE MORPHOLOGY AND BIOLOGY OF *APIOCERA MARITIMA* HARDY
(DIPTERA, APIOCERIDAE).

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(Thirteen Text-figures.)

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INTRODUCTION.

Apiocera maritima was described by Hardy (1933) from 9 specimens collected in Queensland on coastal dunes along the foreshore.

The species is represented in the collections of the Australian Museum, Sydney, by 6 specimens, in the Macleay Museum at Sydney University by 7 specimens, and in the School of Public Health and Tropical Medicine, Sydney, by 2 specimens. For some of these the only locality given is New South Wales, for the others the localities given are on the coast, in the vicinity of Sydney, New South Wales.

The material which forms the subject of this paper was all collected on beaches near Narooma on the south coast of New South Wales.

OCCURRENCE.

All the larvae and most of the adults and pupae were collected on the beach at Mystery Bay, a few miles south of Narooma; some adults and pupae were found on intervening beaches; no other parts of the coast were visited.

Over a number of years intermittent visits were made to Narooma in the months of January, February and early March, adults being taken in each of these months, but there was no opportunity of observing for what further period they were on the wing. The first specimens were a pair taken on 1st March, 1932; another pair was taken in January, 1936. Many were taken in 1938 and 1939 when more preparation had been made for collecting and visits to the beach were more frequent. In January, 1938, and again in January, 1939, dozens of the flies were to be seen resting on the sand in the sun, flying lazily from place to place, and mating. Females were observed moving the apex of the abdomen on the dry sand so that a small depression was formed, but whether this was in preparation for egg-laying or whether eggs had already been deposited was not determined.

In January, 1937, two empty pupal cases were found in a sand-bank at the back of the beach at Mystery Bay, and a pupal case of a different type was found in a similar position on the surfing beach. This suggested that a further search on the sand might prove worth while, and this surmise proved to be correct, for in January, 1938, fifty pupal cases of the first type and twenty-three of the second type, which proved to be the Apiocerid, which is the subject of the present paper, were found at Mystery Bay. On 26th January, 1939, seventy-nine Apiocerid pupal cases were collected at Mystery Bay on a stretch of beach about a quarter of a mile in length, and a few days later sixty-three cases were collected in about half an hour on the same stretch of beach. Some of these were protruding from the wet sand between tide marks, where the flies had recently emerged from them, but most were lying on the dry sand at the back of the beach where they had been blown by the wind, many of these being very weathered. The numbers show what a very prolific breeding ground this spot must have been for a species belonging to a family that is poorly represented in collections, and for which the numbers recorded with descriptions are usually small.

In November, 1938, a special trip to Narooma was made for the purpose of searching for larvae, and a wire sieve with one-fourth of an inch mesh was used with the idea that the larvae might be found by sifting the beach sand. At first no larvae or pupae were found, the places selected for digging evidently being too far back on the beach. Next day, digging and sifting was done nearer high-water mark and 1 active white larva and 2 pupae were found. Some hours' work on the beach daily for ten days yielded 12 large and 6 similar, smaller larvae and 2 pupae, all presumed to be Apioceridae; also 3 Therevid larvae, and 12 larvae and 10 pupae of a Tabanid. The best results on any one day were 6 larvae and 2 pupae of Apioceridae and 2 Tabanid larvae, but on some days none were found. It was difficult to determine at what depth exactly the larvae were present in the sand as several spades full of sand were sifted at a time, but one was uncovered in the sand about three inches from the surface and all were found between two and ten inches down. In January, 1939, 7 larvae and 1 pupa were found by sifting sand.

Of the two pupae found in November, 1938, one was badly damaged by the spade, the other appeared undamaged but it died without emerging. Of the large larvae, four pupated, one was deformed and died, one failed to emerge, from one, a female Apiocerid emerged, and from the fourth, a male emerged; both larval and pupal exuvia of this male specimen were obtained. The pupal periods were twenty and twenty-one days.

The larvae are carnivorous and had to be kept in separate jars. They proved to be very hardy and could probably be reared to maturity under laboratory conditions reasonably easily. One larva, smaller than those which pupated, was kept in moist beach sand (occasionally changed) in a 2-oz. jar from November, 1938, till November, 1939, when a piece of earth-worm was put in the jar; the larva lived till October, 1940, but later died of neglect. Another larger larva, taken in February, 1939, was kept in a similar manner, and it was observed feeding on the piece of earth-worm put in the jar in November, 1939; this larva lived till October, 1940, but later, like the other, was neglected and died.

Eggs.

No eggs were found in the sand nor were any deposited by females in captivity, no suitable cages having been made for keeping them for egg-laying. In February, 1939, the female of a mating pair was captured; she was kept in a small jar and died six days later without depositing eggs. The body contents were removed, as is done with large-bodied Lepidoptera, to see if the specimen would keep better, for these flies often deteriorate because they become very greasy. Eggs formed a large part of the body contents; 69 large ones were obtained and small ones were also seen. They were a creamy colour, long and rounded at the ends, more or less elongated ovate in shape. The largest were 2 mm. in length and 1 mm. in width.

THE LARVA. Text-fig. 1.

The larva is white in colour, long and relatively slim; the largest one measured was 51 mm. in length and 3 mm. in width. The anterior and posterior segments are more or less cylindrical, and the middle segments are noticeably bead-like in shape. There are 12 segments exclusive of the head.

The prothorax is long, it tapers anteriorly and ends in a thickened collar which is broader on the dorsal side, and is covered with very small tubercles. The 2nd thoracic segment is about the same length as the 1st, the 3rd is shorter, and they are both cylindrical in shape. Each thoracic segment carries a pair of short hairs.

The first five abdominal segments are pear-shaped, thicker anteriorly and tapering posteriorly, with a slight constriction posterior to the middle in each one; the 1st segment is shorter than the succeeding ones; these segments give the characteristic bead-like appearance to the body. The 6th, 7th and 8th segments are long and more or less cylindrical. The apical segment is short and the ventral surface curves sharply upwards to meet the dorsal surface in an almost straight transverse keel, slightly chitinized. The anus is situated on the ventral surface, and the segment carries four pairs of hairs, the most posterior pair being much longer than the others. On abdominal segments 2 to 6 there is a suggestion of paired processes on the ventral

surface, marked more by semi-circular depressions than by actual protuberances. These marks are very slight on the 6th segment.

The body is longitudinally striated, and bears on each side a pair of longitudinal furrows, which are deep and well marked anteriorly, but less pronounced posteriorly. The thoracic hairs are situated in the ventral furrow on each side, and all the spiracles are situated laterally between the furrows. Towards the posterior end of each abdominal segment two semi-circular furrows on each side cross the lateral ones and mark out a small upraised area.

The Head. Text-figs. 6, 7 and 8.—The head is well developed, elongated, and the anterior portion is downwardly directed; it can be almost wholly protruded from the first thoracic segment, and it can be retracted into it for nearly half its length. The dorsal surface is strongly arched, the ventral surface being slightly rounded. Placed laterally and extending along the middle two-thirds of the head is a flat keel of transparent chitin; this, together with the rest of the head, becomes dark brown in the larval exuvia, and it gives the head a much broader and flatter appearance than is evident in the larva itself.

The dorsal surface of the epicranium is strongly chitinized, with two longitudinal dark marks showing the internal position of attachment of the more heavily chitinized dorsal rods of the vertical plate. To the centre of the posterior edge is articulated a long chitinized rod, which is very much flattened dorso-ventrally, slightly arched anteriorly, and bent and strongly arched posteriorly; it is nearly twice as long as the head and can be seen through the integument of the prothorax. Melin (1923), in the "Biology, etc., of the Swedish Asilids", calls this the "capsule rod". At each anterior lateral corner of the epicranium, there is a bud-like sensory organ, probably the antenna; some distance behind the antennae, nearer the lateral border on each side, is a long bristle.

The ventral surface of the epicranium is covered for the most part with unchitinized or lightly chitinized membrane, with a large chitinized shield-like ventral plate situated anteriorly. Situated on the membrane at each anterior lateral corner, is a short bristle, and close behind are two long bristles.

Laterally, the epicranium is bordered by the major portion of the lateral keel which extends at its full width from the anterior edge backwards past the middle, then tapers off, leaving bare the posterior portion of the epicranium.

Internally, the anterior median dorsal portion of the epicranium (Text-fig. 9) is occupied by a chitinized box-like structure bounded dorsally by the dorsal rods and the inner surface of the epicranium, laterally by the vertical plates, and ventrally by the ventral rods, which are joined by a narrow strip of thin chitin. Melin (1923) calls a similar structure in the Asilids the "pharynx support". If the membrane is removed from the ventral surface of the epicranium the posterior portion of the ventral rods can be seen extending beyond the ventral plate (Text-fig. 8), and articulated to them posteriorly can be seen also the tentorial rods which extend back into the prothorax. At the anterior edge of the pharynx support, the pharynx opens into the mouth cavity, and posteriorly it runs backwards just above the ventral rods. The oesophagus lies just above the tentorial rods and is apparently supported by them.

The anterior downwardly-directed portion of the head contains the mouth-parts; it is rounded anteriorly and divided vertically by the mouth cavity.

The dorsal surface is strongly arched and is armed with three long bristles on each side posteriorly, and one short bristle on each side anteriorly situated. In the median line, and attached posteriorly to the epicranium, is the labrum, on each side of which can be seen the posterior portion and part of the anterior portion of the heavily chitinized mandibles. On each side of these is a large, more or less triangular, membrane-covered part attached posteriorly to the epicranium; through the membrane can be seen heavily-chitinized parts, the most anterior of these probably representing the maxillae.

The ventral surface is slightly curved and membrane covered, with the chitinized parts showing through more or less faintly. A pair of triangular thickened membranous lobes occupy the posterior half, and in front of these, hanging downwards, is a pair of slender two-jointed bristles.

Laterally, the triangular lobes are bordered by the anterior part of the lateral keel. Also situated laterally is a pair of large two-jointed palpi (Text-fig. 13).

Mouth-Parts. Text-figs. 9 and 10.—The narrow labrum of clear chitin curves slightly downwards to a point anteriorly; it is thicker at the base, the under surface of which forms the dorsal border of the mouth opening; it is armed with dorsal spines near the apex and is toothed on the ventral surface near the base. Below the labrum, in the median line, is the narrow chitinized hypopharynx which is articulated posteriorly to the anterior end of the ventral rods, and is forked at the apex. Below this is the labium, a laterally-compressed structure with a narrow chitinized band above and an almost transparent lobe-like part below, which is covered with hairs and spines. The salivary duct opens below the hypopharynx and runs backwards below the ventral rods of the pharynx-support. Below this a strong muscular complex runs back from the labium.

On each side of the labrum are the strongly chitinized mandibles; the chitin is thick below and curves over above to form a longitudinal canal on the inner surface of each. Each mandible fits into a groove in the dorsal part of the maxillary mouth-part beside it. Below and in front of this groove, the inner membranous faces of the maxillary mouth-parts form the pre-oral cavity. The membrane in the posterior part of this cavity is lined with a criss-cross pattern of fine-toothed ridges; anteriorly, it is lined with fine hairs and filaments, and just below the mandibular groove it is lined with stronger branched filaments.

In slide mounts of the maxillary mouth-parts, near the apex of each, can be seen two sensory canals; one opens by a pore into the ventral part of the pre-oral cavity, and the other by a pore on to the exterior near the apex. Melin (1923) figures similar anterior pores in some species, but he does not mention them in the text, so it is not known whether they represent similar structures.

The Spiracles. Text-figs. 11 and 12.—The anterior spiracles are distinct and situated laterally near the posterior border of the prothorax. The posterior spiracles are large and situated laterally on the anterior part of the penultimate segment. There are also eight pairs of small spiracles situated laterally on the metathorax and abdominal segments 1 to 7. When the larva contracts, the anterior part of the mesothoracic and metathoracic segments folds over, and part of the fold goes on to the segment in front, so that the anterior spiracles can be covered in this way. The posterior part of each abdominal segment folds over and part of the fold goes on to the segment behind, the posterior spiracles often being covered in this way.

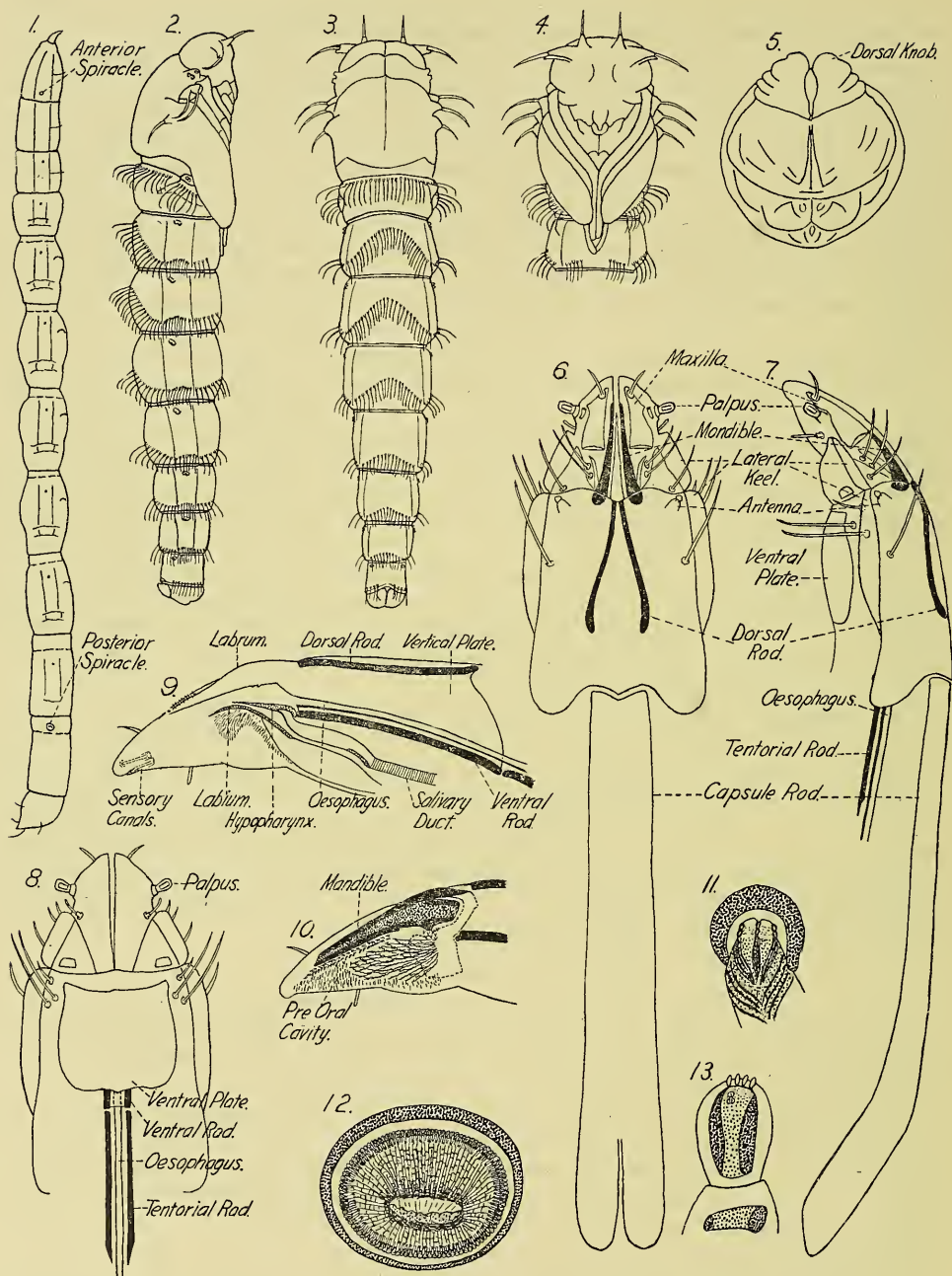
THE PUPA. Text-figs. 2, 3 and 4.

Pupal exuvia vary greatly in size, from 18 mm. to 28 mm. in length, and from 3 mm. to 5 mm. in width; in general, the large sizes are female and the small sizes are males, but the middle sizes may be either; size no doubt is dependent on food supply which for carnivorous larvae must vary considerably.

Male and female pupae can be distinguished though the differences are slight. In the female the abdomen is relatively stouter; also, on the 8th segment, the anal tubercle is well developed and the space between the bristles on the ventral surface is wide; in the male, the anal tubercle is undeveloped and the space between the bristles on the 8th segment is very narrow. There are slight differences also in the markings of the apical segment.

The head is armed with two pairs of strong bristles. The two anterior bristles are usually straight and forwardly directed, each being situated on a tall conical tubercle. The two posterior bristles are curved and directed laterally, each situated, together with a short blunt spine, on a larger conical tubercle.

The thorax is armed with three pairs of strong bristles. Two bristles are situated on adjacent squat tubercles at the base of each middle leg, and there is a single one on a low rounded tubercle at the base of each wing. The thoracic spiracle is elevated, with a well-defined reniform area, and there is a small, but definite, elevation just in front of the spiracle.



Text-figs. 1-13.—*Apiocera maritima*. 1. Larva, lateral view, $\times 3$. 2. Pupa, lateral view, $\times 4$. 3. Pupa, dorsal view, $\times 4$. 4. Anterior end of pupa, ventral view, $\times 4$. 5. Posterior end of male pupa, $\times 16$. 6. Head of larva, dorsal view, $\times 30$. 7. Head of larva, lateral view, $\times 30$. 8. Head of larva, ventral view, $\times 30$. 9. Vertical section of larval head, showing labrum and labium, $\times 50$. 10. Vertical section of larval head, showing mandible and pre-oral cavity, $\times 50$. 11. Anterior spiracle of larva, surface view, $\times 55$. 12. Posterior spiracle of larva, surface view, $\times 55$. 13. Palpus, $\times 100$.

The wing sheaths extend slightly beyond the basal abdominal segment, the apices of the fore-tarsi do not extend as far as the wings, the apices of the mid-tarsi extend beyond the wings, and the apices of the hind-tarsi extend well beyond the apices of the mid-tarsi and beyond the middle of the second abdominal segment.

The abdomen consists of nine segments, all armed with numerous strong bristles, except the last one, which is unarmed. The arrangement of the bristles varies considerably on the segments and the description will be clearer if the surfaces, instead of the segments, are taken separately.

Dorsal surface.—On the 1st segment the line of bristles runs near, and parallel to, the anterior edge. On the 2nd segment the line of bristles is placed towards the posterior edge laterally, and it curves sharply forwards to the centre of the back, where the apex of the curve is near the anterior edge of the segment. On each succeeding segment the lateral bristles are nearer the posterior edge and the curve diminishes, until the 7th segment, where the line of bristles is almost parallel to the posterior edge of the segment. On the 8th segment the centre is devoid of bristles, and those placed laterally are near, and parallel to, the posterior edge.

Ventral surface.—On the 1st segment there are no bristles. On the 2nd segment there are five or six bristles on each side and the centre is bare. On each succeeding segment the width of the bare part is reduced until, on the 7th segment, the line of bristles is continuous; on the 8th segment the centre is bare. On the ventral surface, on all segments, the line of bristles is placed near the posterior edge laterally and it curves forwards slightly in the centre.

Lateral surfaces.—The pleural ridge is well marked except on the 8th and 9th segments. On the first segment the bristles are borne on a marked swelling. On the 2nd segment the bristles are borne on a slight swelling, the line of bristles is placed towards the posterior edge of the segment and it curves forward slightly from the sides. On each succeeding segment the swelling and the curve diminish, and on the 8th segment, the bristles are practically parallel to the posterior edge of the segment. The number of bristles on the pleural ridge varies in different specimens, but it is always more than five.

The abdominal bristles are similar to the thoracic bristles but more slender; they are long and strong and on the anterior segments frequently sharply curved. On each succeeding segment they decrease in strength and curvature and on the posterior segments they are quite straight; each bristle is borne on a slender conical base. There are eight abdominal spiracles situated laterally towards the anterior edge of each segment, except the last; all are borne on small tubercles and have a reniform outline.

The apical segment has no outstanding characters.

The whole abdominal surface is covered with a network of raised lines, the general trend of which is longitudinal.

The morpho-type, consisting of the larval exuvia, together with its corresponding pupal exuvia and the imago, have been deposited in the Macleay Museum at the University of Sydney. Other specimens and slides used in the preparation of this paper have been deposited there also.

CONCLUSION.

There are apparently no previous records of the immature stages of the Apioceridae, and therefore the family is not included in keys for the identification of the larvae and pupae. The latest available key of this kind was published by Brues and Melander (1932), and in this the key for the immature stages of Diptera is based on Malloch (1917), and for the Orthorrhapha, it is unchanged except for some additions to include another family. In the same way, additions could be made to Malloch's key near the Asilidae to include the Apioceridae, using, for the larvae, the long penultimate segment, the variation in shape of the abdominal segments, and the lateral keel on the head; and for the pupae, the uniformity of the abdominal bristles and the unarmed apical segment.

It remains to be seen whether the characters of this species are typical of the family or whether the environment has given rise to specialized characters. However, the description of the immature stages of this one species tends to confirm the position of the Apioceridae as a separate family in the superfamily Asiloidea, where it has been placed on adult characters.

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